



Intel® Celeron® Processor in the 478-Pin Package

Specification Update

May 2003

Notice: The Intel® Celeron® processor in the 478-pin package may contain design defects or errors known as errata which may cause the product to deviate from published specifications. Current characterized errata are documented in this Specification Update.

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The Intel® Celeron® processor in the 478-pin package may contain design defects or errors known as errata which may cause the product to deviate from published specifications. Current characterized errata are available on request.

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Revision History

| Version | Description | Date |
|---------|---|----------------|
| -001 | Initial release. | May 2002 |
| -002 | Added erratum V35. Added Documentation Changes V4-V5. Updated processor identification information table. | June 2002 |
| -003 | Added erratum V37. Added Documentation Changes V3-V12. | July 2002 |
| -004 | Updated with Intel® Celeron® Processor on 0.13 Micron Process and in the 478-Pin Package. Added erratum V38. Updated Erratum V17. Added Documentation Changes V3-V24. | September 2002 |
| -005 | Added erratum V39. Added Documentation Changes V25-V32. | October 2002 |
| -006 | Added Erratum 40. Added Spec Change V1. Added Documentation Changes V1-V10. Updated processor identification information table. | November 2002 |
| -007 | Added Erratum V41. | January 2003 |
| -008 | Added Erratum V42. | February 2003 |
| -009 | Updated Erratum V41. Added erratum V43. Updated processor identification information table | March 2003 |
| -010 | Added Specification clarification V1. Updated processor identification information table. Added Errata V44 and V45. | May 2003 |



Preface

This document is an update to the specifications contained in the documents listed in the following Affected Documents/Related Documents table. It is a compilation of device and document errata and specification clarifications and changes, and is intended for hardware system manufacturers and for software developers of applications, operating system, and tools.

Information types defined in the Nomenclature section of this document are consolidated into this update document and are no longer published in other documents. This document may also contain information that has not been previously published.

Affected Documents

| Document Title | Document Location |
|--|---|
| <i>Intel® Celeron® Processor in the 478-Pin Package up to 1.80 GHz Datasheet</i> | http://developer.intel.com/design/celeron/datashts/290748.htm |

Related Documents

| Document Title | Document Location |
|--|---|
| <i>Intel Architecture Software Developer's Manual, Volume 1: Basic Architecture</i> | http://developer.intel.com/design/pentium4/manuals/245470.htm |
| <i>Intel Architecture Software Developer's Manual, Volume 2: Instruction Set Reference</i> | http://developer.intel.com/design/pentium4/manuals/245471.htm |
| <i>Intel Architecture Software Developer's Manual, Volume 3: System Programming Guide</i> | http://developer.intel.com/design/pentium4/manuals/245472.htm |

Nomenclature

S-Spec Number is a five-digit code used to identify products. Products are differentiated by their unique characteristics, e.g., core speed, L2 cache size, package type, etc. as described in the processor identification information table. Care should be taken to read all notes associated with each S-Spec number.

Errata are design defects or errors. Errata may cause the Intel® Celeron® processor in the 478-pin package's behavior to deviate from published specifications. Hardware and software designed to be used with any given stepping must assume that all errata documented for that stepping are present on all devices.

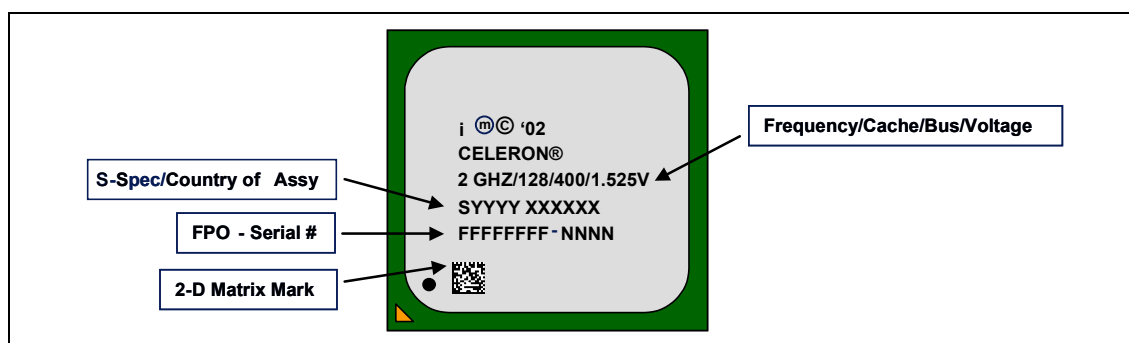
Specification Changes are modifications to the current published specifications. These changes will be incorporated in the next release of the specifications.

Specification Clarifications describe a specification in greater detail or further highlight a specification's impact to a complex design situation. These clarifications will be incorporated in the next release of the specifications.

Documentation Changes include typos, errors, or omissions from the current published specifications. These changes will be incorporated in the next release of the specifications.

General Information

Figure 1. Example Markings for the Intel® Celeron® Processor on 0.13 Micron Process and/or in the 478-Pin Package



Component Marking Information

The Celeron processor in the 478-pin package may be identified by the following component markings:

| Family ¹ | Model ² | Brand ³ |
|---------------------|--------------------|--------------------|
| 1111 | 0001 | 00001010 |
| 1111 | 0010 | 00001010 |

NOTES:

1. The Family corresponds to bits [11:8] of the EDX register after RESET, bits [11:8] of the EAX register after the CUID instruction is executed with a 1 in the EAX register, and the generation field of the Device ID register accessible through Boundary Scan.
2. The Model corresponds to bits [7:4] of the EDX register after RESET, bits [7:4] of the EAX register after the CUID instruction is executed with a 1 in the EAX register, and the model field of the Device ID register accessible through Boundary Scan.
3. The Brand ID corresponds to bits [7:0] of the EBX register after the CUID instruction is executed with a 1 in the EAX register.



| S-Spec | Core Stepping | L2 Cache Size (bytes) | Processor Signature | Speed Core/Bus | Package and Revision | Notes |
|--------|---------------|-----------------------|---------------------|----------------------|------------------------------|-----------|
| SL69Z | E0 | 128K | 0F13h | 1.70 GHz/ 400 MHz | FC-PGA2 35.0 mm, Rev 02 | 1,2 |
| SL68C | E0 | 128K | 0F13h | 1.70 GHz/ 400 MHz | FC-PGA2 35.0 mm, Rev 02 | 1 |
| SL6A2 | E0 | 128K | 0F13h | 1.80 GHz/ 400 MHz | FC-PGA2 35.0 mm, Rev 02 | 2,3 |
| SL68D | E0 | 128K | 0F13h | 1.80 GHz/ 400 MHz | FC-PGA2 35.0 mm, Rev 02 | 3 |
| SL6LC | C1 | 128K | 0F27h | 2 GHz/ 400 MHz | FC-PGA2 31.0 mm , rev 1.0 | 2,4 |
| SL6HY | C1 | 128K | 0F27h | 2 GHz/ 400 MHz | FC-PGA2 31.0 mm , rev 1.0 | 4 |
| SL6RS | C1 | 128K | 0F27h | 2.10 GHz/ 400 MHz | FC-PGA2 31.0 mm , rev 1.0 | 5,10 |
| SL6RW | C1 | 128K | 0F27h | 2.20 GHz/ 400 MHz | FC-PGA2 31.0 mm , rev 1.0 | 6,10 |
| SL6XJ | C1 | 128K | 0F27h | 2.30 GHz/ 400 MHz | FC-PGA2 31.0 mm , rev 1.0 | 6,10 |
| SL6T5 | C1 | 128K | 0F27h | 2.30 GHz/ 400 MHz | FC-PGA2 31.0 mm , rev 1.0 | 2, 6 12 |
| SL6V2 | C1 | 128K | 0F27h | 2.40 GHz/ 400 MHz | FC-PGA2 31.0 mm , rev 1.0 | 10,11 |
| SL6XG | C1 | 128K | 0F27h | 2.40 GHz/ 400 MHz | FC-PGA2 31.0 mm , rev 1.0 | 11, 12 13 |

NOTES:

1. This processor has maximum Tcase of 76 °C.
2. This is a boxed processor with an unattached fan heatsink.
3. This processor has maximum Tcase of 77 °C.
4. This processor has maximum Tcase of 68 °C
5. This processor has maximum Tcase of 69 °C
6. This processor has maximum Tcase of 70 °C
7. This part uses a VCCCORE of 1.475 V.
8. This part uses a VCCCORE of 1.5 V.
9. This part uses a VCCCORE of 1.525 V.
10. This part uses a VCCCORE of 1.475 V, 1.5 V or 1.525 V.
11. This processor has maximum Tcase of 71 °C
12. This part has Multiple VID
13. Some of these processors are offered as boxed processors with an unattached fan heatsink

Summary Tables of Changes

The following table indicates the Specification Changes, Errata, Specification Clarifications or Documentation Changes, which apply to the listed MCH steppings. Intel intends to fix some of the errata in a future stepping of the component, and to account for the other outstanding issues through documentation or Specification Changes as noted. This table uses the following notations:

Codes Used in Summary Table

Stepping

X: Erratum, Specification Change or Clarification that applies to this stepping.

(No mark) or (Blank Box): This erratum is fixed in listed stepping or specification change does not apply to listed stepping.

Status

Doc: Document change or update that will be implemented.

PlanFix: This erratum may be fixed in a future stepping of the product.

Fixed: This erratum has been previously fixed.

NoFix: There are no plans to fix this erratum.

PKG: This column refers to errata on the Celeron processor in the 478-pin package substrate

AP: APIC related erratum.

Shaded: This item is either new or modified from the previous version of the document.

Note: Each Specification Update item is prefixed with a capital letter to distinguish the product. The key below details the letters that are used in Intel's microprocessor Specification Updates:

- A = Intel® Pentium® II processor
- B = Mobile Intel® Pentium® II processor
- C = Intel® Celeron® processor
- D = Intel® Pentium® II Xeon™ processor
- E = Intel® Pentium® III processor
- G = Intel® Pentium® III Xeon™ processor
- H = Mobile Intel® Celeron® processor at 466 MHz, 433 MHz, 400 MHz, 366 MHz, 333 MHz, 300 MHz, and 266 MHz
- K = Mobile Intel® Pentium® III Processor - M
- M = Mobile Intel® Celeron® processor
- N = Intel® Pentium® 4 processor
- O = Intel® Xeon™ processor MP
- P = Intel® Xeon™ processor
- T = Mobile Intel® Pentium® 4 processor – M
- V = Intel® Celeron® processor in the 478-Pin Package

| NO. | E0 | NC1 | Plans | ERRATA |
|-----|----|-----|---------|---|
| V1 | X | X | NoFix | I/O restart in SMM may fail after simultaneous machine check exception (MCE) |
| V2 | X | X | NoFix | MCA registers may contain invalid information if RESET# occurs and PWRGOOD is not held asserted |
| V3 | X | | Fixed | Uncacheable (UC) code in same line as write back (WB) data may lead to data corruption |
| V4 | X | X | NoFix | Transaction is not retried after BINIT# |
| V5 | X | X | NoFix | Invalid opcode 0FFFh requires a ModRM byte |
| V6 | X | X | NoFix | FSW may not be completely restored after page fault on FRSTOR or FLDDENV instructions |
| V7 | X | X | NoFix | The processor flags #PF instead of #AC on an unlocked CMPXCHG8B instruction |
| V8 | X | X | NoFix | When in no-fill mode the memory type of large pages are incorrectly forced to uncacheable |
| V9 | X | X | NoFix | Processor may hang due to speculative page walks to non-existent system memory |
| V10 | X | | Fixed | Writing a performance counter may result in incorrect value |
| V11 | X | X | NoFix | IA32_MC0_STATUS register overflow bit not set correctly |
| V12 | X | | Fixed | Performance counter may contain incorrect value after being stopped |
| V13 | X | | NoFix | MCA error code field in IA32_MC0_STATUS register may become out of sync with the rest of the register |
| V14 | X | | NoFix | The IA32_MC1_STATUS register may contain incorrect information for correctable errors |
| V15 | X | X | NoFix | Debug mechanisms may not function as expected |
| V16 | X | X | NoFix | Machine check architecture error reporting and recovery may not work as expected |
| V17 | X | | Fixed | Processor may timeout waiting for a device to respond after ~0.67 seconds |
| V18 | X | X | NoFix | Cascading of performance counters does not work correctly when forced overflow is enabled |
| V19 | X | | Fixed | IA32_MC1_STATUS MSR ADDRESS VALID bit may be set when no valid address is available |
| V20 | X | X | NoFix | EMON event counting of x87 loads may not work as expected |
| V21 | X | | Fixed | Software controlled clock modulation using a 12.5% or 25% duty cycle may cause the processor to hang |
| V22 | X | | Fixed | SQRTPD and SQRTSD may return QNaN indefinite instead of negative zero |
| V23 | X | X | PlanFix | Bus Invalidate Line requests that return unexpected data may result in L1 cache corruption |
| V24 | X | X | PlanFix | Write Combining (WC) load may result in unintended address on system bus |
| V25 | X | | Fixed | Incorrect data may be returned when page tables are in Write Combining (WC) memory space |
| V26 | X | | PlanFix | Buffer on resistance may exceed specification |
| V27 | X | X | NoFix | Processor issues inconsistent transaction size attributes for locked operation |

| NO. | E0 | NC1 | Plans | ERRATA |
|-----|----|-----|---------|---|
| V28 | X | | Fixed | Multiple accesses to the same S-state L2 cache line and ECC error combination may result in loss of cache coherency |
| V29 | X | | Fixed | Processor may hang when resuming from Deep Sleep state |
| V30 | X | X | NoFix | When the processor is in the System Management Mode (SMM), debug registers may be fully writeable |
| V31 | X | X | NoFix | Associated counting logic must be configured when using Event Selection Control (ESCR) MSR |
| V32 | X | X | NoFix | IA32_MC0_ADDR and IA32_MC0_MISC registers will contain invalid or stale data following a Data, Address, or Response Parity Error |
| V33 | X | | Fixed | CR2 may be incorrect or an incorrect page fault error code may be pushed onto stack after execution of an LSS instruction |
| V34 | X | X | NoFix | System may hang if a fatal cache error causes Bus Write Line (BWL) transaction to occur to the same cache line address as an outstanding Bus Read Line (BRL) or Bus Read-Invalidate Line (BRIL) |
| V35 | X | | Fixed | Processor Does not Flag #GP on Non-zero Write to Certain MSRs |
| V36 | X | | Fixed | L2 cache may contain stale data in the Exclusive state |
| V37 | X | X | NoFix | Simultaneous assertion of A20M# and INIT# may result in incorrect data fetch |
| V38 | X | X | No Fix | Glitches on Address and Data Strobe Signals May Cause System Shutdown |
| V39 | X | | Fixed | CPUID Returns Incorrect Number of ITLB Entries |
| V40 | X | X | NoFix | A Write to APIC Task Priority Register (TPR) That Lowers Priority Sometimes May appear to Have not Occurred |
| V41 | | X | PlanFix | Store to Load Data Forwarding may Result in Switched Data Bytes |
| V42 | | X | No Fix | Parity Error in the L1 Cache may Cause the Processor to Hang |
| V43 | | X | Fixed | The TCK Input in the Test Access Port (TAP) is Sensitive to Low Clock Edge Rates and Prone to Noise Coupling Onto TCK's Rising or Falling Edges |
| V44 | X | X | PlanFix | Re-mapping the APIC base address to a value less than or equal to 0xDC001000 may cause IO and Special Cycle failure |
| V45 | X | X | PlanFix | Erroneous BIST result found in EAX register after reset |



| NO. | E0 | C1 | SPECIFICATION CHANGES |
|-----|----|----|--|
| V1 | X | X | Context ID feature added to CPUID Feature/IA32_MISC_Enable Registers |

| NO. | E0 | C1 | SPECIFICATION CLARIFICATIONS |
|-----|----|----|-------------------------------------|
| V1 | X | X | Thermal Specification Clarification |

| NO. | E0 | C1 | DOCUMENTATION CHANGES |
|-----|----|----|--|
| | | | Refer to Documentation Changes section |

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Errata

V1. I/O Restart in SMM May Fail after Simultaneous Machine Check Exception (MCE)

Problem: If an I/O instruction (IN, INS, REP INS, OUT, OUTS, or REP OUTS) is being executed, and if the data for this instruction becomes corrupted, the processor will signal a Machine Check Exception (MCE). If the instruction is directed at a device that is powered down, the processor may also receive an assertion of SMI#. Since MCEs have higher priority, the processor will call the MCE handler, and the SMI# assertion will remain pending. However, upon attempting to execute the first instruction of the MCE handler, the SMI# will be recognized and the processor will attempt to execute the SMM handler. If the SMM handler is completed successfully, it will attempt to restart the I/O instruction, but will not have the correct machine state, due to the call to the MCE handler.

Implication: A simultaneous MCE and SMI# assertion may occur for one of the I/O instructions above. The SMM handler may attempt to restart such an I/O instruction, but will have an incorrect state due to the MCE handler call, leading to failure of the restart and shutdown of the processor.

Workaround: If a system implementation must support both SMM and board I/O restart, the first thing the SMM handler code should do is check for a pending MCE. If there is an MCE pending, the SMM handler should immediately exit via an RSM instruction and allow the MCE handler to execute. If there is no MCE pending, the SMM handler may proceed with its normal operation.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V2. MCA Registers May Contain Invalid Information If RESET# Occurs and PWRGOOD Is Not Held Asserted

Problem: This erratum can occur as a result either of the following events:

- PWRGOOD is de-asserted during a RESET# assertion causing internal glitches that may result in the possibility that the MCA registers latch invalid information.
- Or, during a reset sequence if the processor's power remains valid regardless of the state of PWRGOOD, and RESET# is re-asserted before the processor has cleared the MCA registers, the processor will begin the reset process again but may not clear these registers.

Implication: When this erratum occurs, the information in the MCA registers may not be reliable.

Workaround: Ensure that PWRGOOD remains asserted throughout any RESET# assertion and that RESET# is not re-asserted while PWRGOOD is de-asserted.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V3. Uncacheable (UC) Code in Same Line As Write Back (WB) Data May Lead to Data Corruption

Problem: When both code (being accessed as UC or WC) and data (being accessed as WB) are aliased into the same cache line, the UC fetch will cause the processor to self-snoop and generate an implicit writeback. The data supplied by this implicit writeback may be corrupted due to the way the processor handles self-modifying code.

Implication: UC or WC code located in the same cache line as WB data may lead to data corruption.

Workaround: UC or WC code should not be located in the same physical 64-byte cache line as any location that is being stored to with WB data

Status: For the steppings affected, see the *Summary Tables of Changes*.

V4. Transaction Is Not Retried after BINIT#

Problem: If the first transaction of a locked sequence receives a HITM# and DEFER# during the snoop phase it should be retried and the locked sequence restarted. However, if BINIT# is also asserted during this transaction, it will not be retried.

Implication: When this erratum occurs, locked transactions will unexpectedly not be retried.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V5. Invalid Opcode 0FFFh Requires a ModRM Byte

Problem: Some invalid opcodes require a ModRM byte (or other following bytes), while others do not. The invalid opcode 0FFFh did not require a ModRM byte in previous generation Intel® architecture processors, but does in the Intel® Pentium® 4 processor.

Implication: The use of an invalid opcode 0FFFh without the ModRM byte may result in a page or limit fault on the Pentium 4 processor.

Workaround: Use a ModRM byte with invalid 0FFFh opcode.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V6. FSW May Not Be Completely Restored after Page Fault on FRSTOR or FLDENV Instructions

Problem: If the FPU operating environment or FPU state (operating environment and register stack) being loaded by an FLDENV or FRSTOR instruction wraps around a 64-Kbyte or 4-Gbyte boundary and a page fault (#PF) or segment limit fault (#GP or #SS) occurs on the instruction near the wrap boundary, the upper byte of the FPU status word (FSW) might not be restored. If the fault handler does not restart program execution at the faulting instruction, stale data may exist in the FSW.

Implication: When this erratum occurs, stale data will exist in the FSW.

Workaround: Ensure that the FPU operating environment and FPU state do not cross 64Kbyte or 4Gbyte boundaries. Alternately, ensure that the page fault handler restarts program execution at the faulting instruction after correcting the paging problem.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V7. The Processor Flags #PF Instead of #AC on an Unlocked CMPXCHG8B Instruction

Problem: If a data page fault (#PF) and alignment check fault (#AC) both occur for an unlocked CMPXCHG8B instruction, then #PF will be flagged.

Implication: Software that depends #AC before #PF will be affected since #PF is flagged in this case.

Workaround: Remove the software's dependency on the fact that #AC has precedence over #PF. Alternately, reload the page in the page fault handler and then restart the faulting instruction.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V8. When in No-Fill Mode the Memory Type of Large Pages Are Incorrectly Forced to Uncacheable

Problem: When the processor is operating in No-Fill Mode (CR0.CD=1), the paging hardware incorrectly forces the memory type of large (PSE-4M and PAE-2M) pages to uncacheable (UC) memory type regardless of the MTRR settings. By forcing the memory type of these pages to UC, load operations, which should hit valid data in the L1 cache, are forced to load the data from system memory. Some applications will lose the performance advantage associated with the caching permitted by other memory types.

Implication: This erratum may result in some performance degradation when using no-fill mode with large pages.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V9. Processor May Hang Due to Speculative Page Walks to Non-Existent System Memory

Problem: A load operation that misses the Data Translation Lookaside Buffer (DTLB) will result in a page-walk. If the page-walk loads the Page Directory Entry (PDE) from cacheable memory and that PDE load returns data that points to a valid Page Table Entry (PTE) in uncacheable memory the processor will access the address referenced by the PTE. If the address referenced does not exist the processor will hang with no response from system memory.

Implication: Processor may hang due to speculative page walks to non-existent system memory.

Workaround: Page directories and page tables in UC memory space which are marked valid must point to physical addresses that will return a data response to the processor.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V10. Writing a Performance Counter May Result in Incorrect Value

Problem: When a performance counter is written and the event counter for the event being monitored is non-zero, the performance counter will be incremented by the value on that event counter. Because the upper eight bits of the performance counter are not written at the same time as the lower 32 bits, the increment due to the non-zero event counter may cause a carry to the upper bits such that the performance counter contains a value about four billion (2³²) higher than what was written.

Implication: When this erratum occurs, the performance counter will contain a different value from that which was written.

Workaround: If the performance counter is set to select a null event and the counter configuration and control register (CCCR) for that counter has its compare bit set to zero, before the performance counter is written, this erratum will not occur. Since the lower 32 bits will always be correct, event counting which does not exceed 2³² events will not be affected.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V11. IA32_MC0_STATUS Register Overflow Bit Not Set Correctly

Problem: The #! Overflow Error bit (bit 62) in the IA32_MC0_STATUS register indicates, when set, that a machine check error occurred while the results of a previous error were still in the error reporting bank (i.e. the valid bit was set when the new error occurred). In the case of this erratum, if an uncorrectable error is logged in the error-reporting bank and another error occurs, the overflow bit will not be set.

Implication: When this erratum occurs the overflow bit will not be set.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.



V12. Performance Counter May Contain Incorrect Value after Being Stopped

Problem: If a performance counter is stopped on the precise internal clock cycle where the intermediate carry from the lower 32 bits of the counter to the upper eight bits occurs, the intermediate carry is lost.

Implication: When this erratum occurs, the performance counter will contain a value about 4 billion (2^{32}) less than it should.

Workaround: Since this erratum does not occur if the performance counters are read when running, a possible workaround is to read the counter before stopping it. Since the lower 32 bits will always be correct, event counting which does not exceed 2^{32} events will not be affected.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V13. MCA Error Code Field in IA32_MC0_STATUS Register May become out of Sync with the Rest of the Register

Problem: The MCA Error Code field of the IA32_MC0_STATUS register gets written by a different mechanism than the rest of the register. For uncorrectable errors, the other fields in the IA32_MC0_STATUS register are only updated by the first error. Any subsequent errors cause the Overflow Error bit to be asserted until this register is cleared. Because of this erratum, any further errors that are detected will update the MCA Error Code field without updating the rest of the register, thereby leaving the IA32_MC0_STATUS register with stale information.

Implication: When this erratum occurs, the IA32_MC0_STATUS register contains stale information.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V14. The IA32_MC1_STATUS Register May Contain Incorrect Information for Correctable Errors

Problem: When a speculative load operation hits the L2 cache and receives a correctable error, the IA32_MC1_STATUS register may be updated with incorrect information. The IA32_MC1_STATUS register should not be updated for speculative loads.

Implication: When this erratum occurs, the IA32_MC1_STATUS register will contain incorrect information for correctable errors.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V15. Debug Mechanisms May Not Function As Expected

Problem: Certain debug mechanisms may not function as expected on the processor. The cases are as follows:

- When the following conditions occur: 1) An FLD instruction signals a stack overflow or underflow, 2) the FLD instruction splits a page-boundary or a 64-byte cache line boundary, 3) the instruction matches a Debug Register on the high page or cache line respectively, and 4) the FLD has a stack fault and a memory fault on a split access, the processor will only signal the stack fault and the debug exception will not be taken.
- When a data breakpoint is set on the ninth and/or tenth byte(s) of a floating point store using the Extended Real data type, and an unmasked floating point exception occurs on the store, the breakpoint will not be captured.
- When any instruction has multiple debug register matches, and any one of those debug registers is enabled in DR7, all of the matches should be reported in DR6 when the processor goes to the debug handler. This is not true during a REP instruction. As an example, during execution of a REP MOVSW instruction the first iteration a load matches DR0 and DR2 and sets DR6 as FFFF0FF5h. On a subsequent iteration of the instruction, a load matches only DR0. The DR6 register is expected to still contain FFFF0FF5h, but the processor will update DR6 to FFFF0FF1h.
- A data breakpoint that is set on a load to uncacheable memory may be ignored due to an internal segment register access conflict. In this case the system will continue to execute instructions, bypassing the intended breakpoint. Avoiding having instructions that access segment descriptor registers e.g., LGDT, LIDT close to the UC load, and avoiding serialized instructions before the UC load will reduce the occurrence of this erratum.

Implication: Certain debug mechanisms do not function as expected on the processor.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V16. Machine Check Architecture Error Reporting and Recovery May Not Work As Expected

Problem: When the processor detects errors it should attempt to report and/or recover from the error. In the situations described below, the processor does not report and/or recover from the error(s) as intended.

- When a transaction is deferred during the snoop phase and subsequently receives a Hard Failure response, the transaction should be removed from the bus queue so that the processor may proceed. Instead, the transaction is not properly removed from the bus queue, the bus queue is blocked, and the processor will hang.
- When a hardware prefetch results in an uncorrectable tag error in the L2 cache, IA32_MC0_STATUS.UNCOR and IA32_MC0_STATUS.PCC are set but no Machine Check Exception (MCE) is signaled. No data loss or corruption occurs because the data being prefetched has not been used. If the data location with the uncorrectable tag error is subsequently accessed, an MCE will occur. However, upon this MCE, or any other subsequent MCE, the information for that error will not be logged because IA32_MC0_STATUS.UNCOR has already been set and the MCA status registers will not contain information about the error which caused the MCE assertion but instead will contain information about the prefetch error event.



- When the reporting of errors is disabled for Machine Check Architecture (MCA) Bank 2 by setting all IA32_MC2_CTL register bits to 0, uncorrectable errors should be logged in the IA32_MC2_STATUS register but no machine-check exception should be generated. Uncorrectable loads on bank 2, which would normally be logged in the IA32_MC2_STATUS register, are not logged.
- When one half of a 64 byte instruction fetch from the L2 cache has an uncorrectable error and the other 32 byte half of the same fetch from the L2 cache has a correctable error, the processor will attempt to correct the correctable error but cannot proceed due to the uncorrectable error. When this occurs the processor will hang.
- When an L1 cache parity error occurs, the cache controller logic should write the physical address of the data memory location that produced that error into the IA32_MC1_ADDR register. In some instances of a parity error on a load operation that hits the L1 cache, however, the cache controller logic may write the physical address from a subsequent load or store operation into the IA32_MC1_ADDR register.
- The local xAPIC has an Error Status Register which records all errors which it detects. Bit 6 of this register, the Receive Illegal Vector bit, is set when the local xAPIC detects an illegal vector in a message that it received. When an illegal vector error is received on the same internal clock that the error status register is being written due to a previous error, bit 6 does not get set and illegal vector errors are not flagged.
- If an instruction fetch results in an uncorrectable error and there is also a debug breakpoint at this address, the processor will livelock and the uncorrectable error will not be logged in the machine check registers.
- The MCA Overflow bit should be set when an uncorrectable error resides within the register bank (valid bit is already set) and any subsequent errors occur. The Overflow bit being set indicates that more than one error has occurred. Because of this erratum, if any further errors occur, the MCA Overflow bit will not be updated; thereby incorrectly indicating only one error has been received.

Implication: The processor is unable to correctly report and/or recover from certain errors.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V17. Processor May Timeout Waiting for a Device to Respond after 0.67 Seconds

Problem: The PCI 2.1 target initial latency specification allows two seconds for a device to respond during initialization-time. The processor may timeout after only approximately 0.67 seconds. When the processor times out it will hang with IERR# asserted. PCI devices that take longer than 0.67 seconds to initialize may not be initialized properly.

Implication: System may hang with IERR# asserted.

Workaround: Due to the long initialization time observed on some commercially available PCI cards, it may be necessary to disable the timeout counter during the PCI initialization sequence. This can be accomplished by temporarily setting Bit 5 of the MISC_ENABLES_MSR located at address 1A0H to 1. This model specific register (MSR) is software visible but should only be set for the duration of the PCI initialization sequence. It is necessary to re-enable the timeout counter by clearing this bit after completing the PCI initialization sequence. CAUTION: The processor's Thermal Monitor feature may not function if the timeout counter is not re-enabled after completing the PCI initialization.

After the system is fully initialized, this erratum may occur either when a PCI device is hot added into the system or when a PCI device is transitioned from D3 cold. System software responsible for completing the hot add and the power state transition from D3 cold should allow for a delay of the target initial latency prior to initiating configuration accesses to the PCI device.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V18. Cascading of Performance Counters Does Not Work Correctly When Forced Overflow Is Enabled

Problem: The performance counters are organized into pairs. When the CASCADE bit of the Counter Configuration Control Register (CCCR) is set, a counter that overflows will continue to count in the other counter of the pair. The FORCE_OVF bit forces the counters to overflow on every non-zero increment. When the FORCE_OVF bit is set, the counter overflow bit will be set but the counter no longer cascades.

Implication: The performance counters do not cascade when the FORCE_OVF bit is set.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.



V19. IA32_MC1_STATUS MSR ADDRESS VALID Bit May Be Set When No Valid Address Is Available

Problem: The processor should only log the address for L1 parity errors in the IA32_MC1_STATUS MSR if a valid address is available. If a valid address is not available, the ADDRESS VALID bit in the IA32_MC1_STATUS MSR should not be set. In instances where an L1 parity error occurs and the address is not available because the linear to physical address translation is not complete or an internal resource conflict has occurred, the ADDRESS VALID bit is incorrectly set.

Implication: The ADDRESS VALID bit is set even though the address is not valid.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V20. EMON Event Counting of x87 Loads May Not Work As Expected

Problem: If a performance counter is set to count x87 loads and floating-point exceptions are unmasked, the FPU Operand Data Pointer (FDP) may become corrupted.

Implication: When this erratum occurs, the FPU Operand Data Pointer (FDP) may become corrupted.

Workaround: This erratum will not occur with floating point exceptions masked. If floating-point exceptions are unmasked, then performance counting of x87 loads should be disabled.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V21. Software Controlled Clock Modulation Using a 12.5% or 25% Duty Cycle May Cause the Processor to Hang

Problem: Processor clock modulation may be controlled via a processor register (IA32_THERM_CONTROL). The On-Demand Clock Modulation Duty Cycle is controlled by bits 3:1. If these bits are set to a duty cycle of 12.5% or 25%, the processor may hang while attempting to execute a floating-point instruction. In this failure, the last instruction pointer (LIP) is pointing to a floating-point instruction whose instruction bytes are in UC space and which takes an exception 16 (floating point error exception). The processor stalls trying to fetch the bytes of the faulting floating-point instruction and those following it. This processor hang is caused by interactions between thermal control circuit and floating-point event handler.

Implication: The processor will go into a sleep state from which it fails to return.

Workaround: Use a duty cycle other than 12.5% or 25%.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V22. SQRTPD and SQRTSD May Return QNaN Indefinite Instead of Negative Zero

Problem: When DAZ mode is enabled, and a SQRTPD or SQRTSD instruction has a negative denormal operand, the instruction will return a QNaN indefinite when the specified response should be a negative zero.

Implication: When this erratum occurs, the instruction will return a QNaN indefinite when a negative zero is expected.

Workaround: Ensure that negative denormals are not used as operands to the SQRTPD or SQRTSD instructions when DAZ mode is enabled. Software could enable FTZ mode to ensure that negative denormals are not generated by computation prior to execution of a SQRTPD or SQRTSD instruction.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V23. Bus Invalidate Line Requests That Return Unexpected Data May Result in L1 Cache Corruption

Problem: When a Bus Invalidate Line (BIL) request receives unexpected data from a deferred reply, and a store operation write combines to the same address, there is a small window where the L0 is corrupt, and loads can retire with this corrupted data. This erratum occurs in the following scenario:

- A Read-For-Ownership (RFO) transaction is issued by the processor and hits a line in shared state in the L1 cache.
- The RFO is then issued on the system bus as a 0 length Read-Invalidate (a BIL), since it doesn't need data, just ownership of the cache line.
- This transaction is deferred by the chipset.
- At some later point, the chipset sends a deferred reply for this transaction with an implicit write-back response. For this erratum to occur, no snoop of this cache line can be issued between the BIL and the deferred reply.
- The processor issues a write-combining store to the same cache line while data is returning to the processor. This store straddles an 8-byte boundary.
- Due to an internal boundary condition, a time window exists where the L1 cache contains corrupt data which could be accessed by a load.

Implication: No known commercially available chipsets trigger the failure conditions.

Workaround: The chipset could issue a BIL (snoop) to the deferred processor to eliminate the failure conditions.

Status: For the steppings affected, see the *Summary Tables of Changes*.



V24. Write Combining (WC) Load May Result in Unintended Address on System Bus

Problem: When the processor performs a speculative write combining (WC) load, down the path of a mispredicted branch, and the address happens to match a valid UnCacheable (UC) address translation with the Data Translation Look-Aside Buffer, an unintended UnCacheable load operation may be sent out on the system bus.

Implication: When this erratum occurs, an unintended load may be sent on system bus. Intel has only encountered this erratum during pre-silicon simulation.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V25. Incorrect Data May be Returned When Page Tables Are In Write Combining (WC) Memory Space

Problem: If page directories and/or page tables are located in Write Combining (WC) memory, speculative loads to cacheable memory may complete with incorrect data.

Implication: Cacheable loads to memory mapped using page tables located in write combining memory may return incorrect data. Intel has not been able to reproduce this erratum with commercially available software.

Workaround: Do not place page directories and/or page tables in WC memory.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V26. Buffer On Resistance May Exceed Specification

Problem: The datasheet specifies the resistance range for RON (Buffer On Resistance) for the AGTL+ and Asynchronous GTL+ buffers as 5 to 11 ohms. Due to this erratum, RON may be as high as 13.11 ohms.

Implication: The RON value affects the voltage level of the signals when the buffer is driving the signal low. A higher RON may adversely affect the system's ability to meet specifications such as VIL. As the system design also affects margin to specification, designs may or may not have sufficient margin to function properly with an increased RON. System designers should evaluate whether a particular system is affected by this erratum. Designs that follow the recommendations in the *Intel® Pentium® 4 Processor and Intel® 850 Chipset Platform Design Guide* are not expected to be affected.

Workaround: No workaround is necessary for systems with margin sufficient to accept a higher RON.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V27. Processor Issues Inconsistent Transaction Size Attributes for Locked Operation

Problem: When the processor is in the Page Address Extension (PAE) mode and detects the need to set the Access and/or Dirty bits in the page directory or page table entries, the processor sends an 8-byte load lock onto the system bus. A subsequent 8-byte store unlock is expected, but instead a 4-byte store unlock occurs. Correct data is provided since only the lower bytes change, however external logic monitoring the data transfer may be expecting an 8-byte store unlock.

Implication: No known commercially available chipsets are affected by this erratum.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V28. Multiple Accesses to the Same S-State L2 Cache Line and ECC Error Combination May Result in Loss of Cache Coherency

Problem: When a Read for Ownership (RFO) cycle has a 64-bit address match with an outstanding read hit on a line in the L2 cache which is in the S-state AND that line contains an ECC error, the processor should recycle the RFO until the ECC error is handled. Due to this erratum, the processor does not recycle the RFO and attempts to service both the RFO and the read hit at the same time.

Implication: When this erratum occurs, cache may become incoherent.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V29. Processor May Hang When Resuming from Deep Sleep State

Problem: When resuming from the Deep Sleep state the address strobe signals (ADSTB[1:0]#) may become out of phase with respect to the system bus clock (BCLK).

Implication: When this erratum occurs, the processor will hang.

Workaround: The system BIOS should prevent the processor from going to the Deep Sleep state.

Status: For the steppings affected, see the *Summary Tables of Changes*.



V30. When the Processor Is in the System Management Mode (SMM), Debug Registers May Be Fully Writeable

Problem: When in System Management Mode (SMM), the processor executes code and stores data in the SMRAM space. When the processor is in this mode and writes are made to DR6 and DR7, the processor should block writes to the reserved bit locations. Due to this erratum, the processor may not block these writes. This may result in invalid data in the reserved bit locations.

Implication: Reserved bit locations within DR6 and DR7 may become invalid.

Workaround: Software may perform a read/modify/write when writing to DR6 and DR7 to ensure that the values in the reserved bits are maintained.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V31. Associated Counting Logic Must Be Configured When Using Event Selection Control (ESCR) MSR

Problem: ESCR MSRs allow software to select specific events to be counted, with each ESCR usually associated with a pair of performance counters. ESCRs may also be used to qualify the detection of at-retirement events that support precise-event-based sampling (PEBS). A number of performance metrics that support PEBS require a 2nd ESCR to tag uops for the qualification of at-retirement events. (The first ESCR is required to program the at-retirement event.) Counting is enabled via counter configuration control registers (CCCR) while the event count is read from one of the associated counters. When counting logic is configured for the subset of at-retirement events that require a 2nd ESCR to tag uops, at least one of the CCCRs in the same group of the 2nd ESCR must be enabled.

Implication: If no CCCR/counter is enabled in a given group, the ESCR in that group that is programmed for tagging uops will have no effect. Hence a subset of performance metrics that require a 2nd ESCR for tagging uops may result in 0 count.

Workaround: Ensure that at least one CCCR/counter in the same group as the tagging ESCR is enabled for those performance metrics that require two ESCRs and tagging uops for at-retirement counting.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V32. IA32_MC0_ADDR and IA32_MC0_MISC Registers Will Contain Invalid or Stale Data Following a Data, Address, or Response Parity Error

Problem: If the processor experiences a data, address, or response parity error, the ADDR_V and MISC_V bits of the IA32_MC0_STATUS register are set, but the IA32_MC0_ADDR and IA32_MC0_MISC registers are not loaded with data regarding the error.

Implication: When this erratum occurs, the IA32_MC0_ADDR and IA32_MC0_MISC registers will contain invalid or stale data.

Workaround: Ignore any information in the IA32_MC0_ADDR and IA32_MC0_MISC registers after a data, address or response parity error.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V33. CR2 May Be Incorrect or an Incorrect Page Fault Error Code May Be Pushed onto Stack after Execution of an LSS Instruction

Problem: Under certain timing conditions, the internal load of the selector portion of the LSS instruction may complete with potentially incorrect speculative data before the load of the offset portion of the address completes. The incorrect data is corrected before the completion of the LSS instruction but the value of CR2 and the error code pushed on the stack are reflective of the speculative state. Intel has not observed this erratum with commercially available software.

Implication: When this erratum occurs, the contents of CR2 may be off by two, or an incorrect page fault error code may be pushed onto the stack.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V34. ProSystem May Hang If a Fatal Cache Error Causes Bus Write Line (BWL) Transaction to Occur to the Same Cache Line Address As an Outstanding Bus Read Line (BRL) or Bus Read-Invalidate Line (BRIL)

Problem: A processor internal cache fatal data ECC error may cause the processor to issue a BWL transaction to the same cache line address as an outstanding BRL or BRIL. As it is not typical behavior for a single processor to have a BWL and a BRL/BRIL concurrently outstanding to the same address, this may represent an unexpected scenario to system logic within the chipset.

Implication: The processor may not be able to fully execute the machine check handler in response to the fatal cache error if system logic does not ensure forward progress on the system bus under this scenario.

Workaround: System logic should ensure completion of the outstanding transactions. Note that during recovery from a fatal data ECC error, memory image coherency of the BWL with respect to BRL/BRIL transactions is not important. Forward progress is the primary requirement.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V35. Processor Does not Flag #GP on Non-Zero Write to Certain MSRs

Problem: When a non-zero write occurs to the upper 32 bits of IA32_CR_SYSENTER_EIP or IA32_CR_SYSENTER_ESP, the processor should indicate a general protection fault by flagging #GP. Due to this erratum, the processor does not flag #GP.

Implication: The processor unexpectedly does not flag #GP on a non-zero write to the upper 32 bits of IA32_CR_SYSENTER_EIP or IA32_CR_SYSENTER_ESP. No known commercially available operating system has been identified to be affected by this erratum.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.



V36. L2 Cache May Contain Stale Data in the Exclusive State

Problem: If a cacheline (A) is in Modified (M) state in the write-combining (WC) buffers and in the Invalid (I) state in the L2 cache and its adjacent sector (B) is in the Invalid (I) state and the following scenario occurs:

1. A read to B misses in the L2 cache and allocates cacheline B and its associated second-sector prefetch into an almost full bus queue,
2. A Bus Read Line (BRL) to cacheline B completes with HIT# and fills data in Shared (S) state,
3. The bus queue full condition causes the prefetch to cacheline A to be cancelled, cacheline A will remain M in the WC buffers and I in the L2 while cacheline B will be in the S state.

Then, if the further conditions occur:

1. Cacheline A is evicted from the WC Buffers to the bus queue which is still almost full,
2. A hardware prefetch Read for Ownership (RFO) to cacheline B, hits the S state in the L2 and observes cacheline A in the I state, allocates both cachelines,
3. An RFO to cacheline A completes before the WC Buffers write modified data back, filling the L2 with stale data,
4. The writeback from the WC Buffers completes leaving stale data, for cacheline A, in the Exclusive (E) state in the L2 cache.

Implication: Stale data may be consumed leading to unpredictable program execution. Intel has not been able to reproduce this erratum with commercial software.

Workaround: It is possible for BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V37. Simultaneous Assertion of A20M# and INIT# may Result in Incorrect Data Fetch

Problem: If A20M# and INIT# are simultaneously asserted by software, followed by a data access to the 0xFFFFFXXX memory region, with A20M# still asserted, incorrect data will be accessed. With A20M# asserted, an access to 0xFFFFFXXX should result in a load from physical address 0xFFEFFXXX. However, in the case of A20M# and INIT# being asserted together, the data load will actually be from the physical address 0xFFFFFXXX. Code accesses are not affected by this erratum

Implication: Processor may fetch incorrect data, resulting in BIOS failure.

Workaround: Deasserting and reasserting A20M# prior to the data access will workaround this erratum.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V38. Glitches on Address or Data Strobe Signals May Cause System Shutdown

Problem: When a Machine Check Exception is generated due to a glitch on the address or data strobe signals, the exception may be reported repeatedly, resulting in system shutdown.

Implication: If a glitch occurs on the address or data strobe signals, an operating system shutdown will occur if Machine Check Exceptions (MCE) are enabled. IERR# assertion and shutdown will occur if MCE is disabled.

Workaround: Correct design and implementation of the processor system bus will remove the possibility of this failure.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V39. CPUID Instruction Returns Incorrect Number of ITLB Entries

Problem: When CPUID instruction is executed with EAX = 2 it should return a value of 51h in EAX[15:8] to indicate that the Instruction Translation Lookaside Buffer (ITLB) has 128 entries. Due to this erratum, the processor returns 50h (64 entries).

Implication: Software may incorrectly report the number of ITLB entries. Operation of the processor is not affected.

Workaround: None identified.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V40. A Write to APIC Task Priority Register (TPR) That Lowers Priority Sometimes May Appear to Have Not Occurred

Problem: Un-cacheable stores to the APIC space are handled in a non-synchronized way with respect to the speed at which instructions are retired. If an instruction that masks the interrupt flag, e.g., CLI, is executed soon after an un-cacheable write to the TPR that lowers the APIC priority, the interrupt masking operation may take effect before the actual priority has been lowered. This may cause interrupts whose priority is lower than the initial TPR but higher than the final TPR to not be serviced until the interrupt flag is finally cleared, e.g., by STI. Interrupts will remain pending and are not lost.

Implication: This condition may allow interrupts to be accepted by the processor but may delay their service.

Workaround: This can be avoided by issuing a TPR Read after a TPR Write that lowers the TPR value. This will force the store to the APIC priority resolution logic before any subsequent instructions are executed. No commercial operating system is known to be impacted by this erratum.

Status: For the steppings affected, see the *Summary Tables of Changes*.



V41. Store to Load Data Forwarding may Result in Switched Data Bytes

Problem: If in a short window after an instruction that updates a segment register has executed, but has not yet retired, there is a load occurring to an address, that matches a recent previous store operation, but the data size is smaller than the size of the store, the resulting data forwarded from the store to the load may have some of the lower bytes switched.

Implication: If this erratum occurs, the processor may execute with incorrect data.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V42. Parity Error in the L1 Cache may Cause the Processor to Hang

Problem: If a locked operation accesses a line in the L1 cache that has a parity error, it is possible that the processor may hang while trying to evict the line.

Implication: If this erratum occurs, it may result in a system hang. Intel has not observed this erratum with any commercially available software

Workaround: None

Status: For the steppings affected, see the *Summary Tables of Changes*.

V43. The TCK Input in the Test Access Port (TAP) is Sensitive to Low Clock Edge Rates and Prone to Noise Coupling Onto TCK's Rising or Falling Edges

Problem: TCK is susceptible to double clocking when low amplitude noise occurs on TCK edge, while it is crossing the receiver's transition region. TAP failures tend to increase with increases in background system noise.

Implication: This only impacts JTAG/TAP accesses to the processor. Other bus accesses are not affected.

Workaround: To minimize the effects of this issue, reduce noise on the TCK-net at the processor relative to ground, and position TCK relative to BCLK to minimize the TAP error rate. Decreasing rise times to under 800 ps reduces the failure rate but does not stop all failures.

Status: For the steppings affected, see the *Summary Tables of Changes*.

V44. Re-Mapping The APIC Base Address to a Value Less Than or Equal to 0xDC001000 May Cause IO and Special Cycle Failure

Problem: Remapping the APIC base address from its default can cause conflicts with either I/O or special cycle bus transactions.

Implication: Either I/O or special cycle bus transactions can be redirected to the APIC, instead of appearing on the front-side bus.

Workaround: Use any APIC base addresses above 0xDC001000 as the relocation address.

Status: For the steppings affected, see the *Summary Table of Changes*

V45. Erroneous BIST Result Found in EAX Register after Reset

Problem: The processor may show an erroneous BIST (built-in self test) result in the EAX register bit 0 after coming out of reset.

Implication: When this erratum occurs, an erroneous BIST failure will be reported in the EAX register bit 0, however this failure can be ignored since it is not accurate.

Workaround: It is possible for BIOS to workaround this issue by masking off bit 0 in the EAX register where BIST results are written.

Status: For the steppings affected, see the *Summary Table of Changes*.



Specification Changes

The Specification Changes listed in this section apply to the following documents:

- *Intel® Celeron® Processor in the 478-Pin Package Datasheet*
- *Intel® Architecture Software Developer's Manual*, Volumes 1, 2, and 3

All Specification Changes will be incorporated into a future version of the appropriate Celeron processor documentation.

V1. Context ID Feature Added to the CPUID Instruction Feature Flags/IA32_MISC_ENABLE Registers

IA32_MISC_ENABLE register, bit 24 status has changed from Reserved to the following definition:

IA32_MISC_ENABLE – Miscellaneous Enables Register, bit # 24
MSR Address: 01A0h Accessed as a Qword
Default Value: High Dword XXXX XXXXh
Low Dword XXXX XXXX XXXX XXXX XXXX XX00 X0X0 0001b
Access: Read/Write
Type: Shared

IA32_MISC_ENABLE is a 64-bit register accessed only when referenced as a Qword through a RDMSR or WRMSR instruction.

Bit 24 of the IA32_MISC_ENABLE status has changed from Reserved to the following:

| Bit | Descriptions |
|-----|---|
| 24 | L1 Data Cache Context Mode (R/W). When set to a '1' this bit places the L1 Data Cache into shared mode. When set to a '0' (default) this bit places the L1 Data Cache into adaptive mode. When this bit is set to a '0', adaptive mode, the Page Directory Base Register contained in CR3 must be identical across all logical processors. Note: If the Context ID feature flag, ECX[10], is not set to a '1' after executing the CPUID instruction with EAX = 1, then this feature is not supported and BIOS must not alter the contents of this bit location. |

In the CPUID instruction function 1 feature information, bit 10 of ECX register (ECX[10]) has been assigned flag to identify "Context ID feature." The status has change from Reserved to the following:

| ECX [Bits] | Descriptions of Feature Flag Value |
|------------|--|
| 10 | Context ID. A value of 1 indicates the L1 data cache mode can be set to either adaptive mode or shared mode. A value of 0 indicates this feature is not supported. See definition of the IA32_MISC_ENABLE MSR Bit 24 (L1 Data Cache Context Mode) for more details. |

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Specification Clarifications

The Specification Clarifications listed in this section apply to the following documents:

- *Intel® Celeron® Processor in the 478-Pin Package Datasheet*
- *Intel® Architecture Software Developer's Manual*, Volumes 1, 2, and 3

All Specification Clarifications will be incorporated into a future version of the appropriate Celeron processor documentation.

V1. Thermal Specification Clarification

In the “Thermal Specifications and Design Considerations” section of the *Intel® Celeron® Processor on 0.13 Micron Process in 478-Pin Package Electrical, Mechanical, and Thermal Specifications (EMTS)* and the *Intel® Celeron® Processor on 0.13 Micron Process in 478-Pin Package Datasheet* thermal specification verbiage has now changed to emphasize the long-term reliability performance degradation if the thermal solutions are under-designed. In order to clarify the purpose of the thermal monitor feature, the description in that section was modified. This change will be incorporated in the next revision of the *Intel® Celeron® Processor on 0.13 Micron Process in 478-Pin Package Electrical, Mechanical, and Thermal Specifications (EMTS)* and the *Intel® Celeron® Processor on 0.13 Micron Process in 478-Pin Package Datasheet*. See below for thermal specification clarification changes.

EMTS Thermal section (Chapter 6):

6 Thermal Specifications and Design Considerations

6.1 Processor Thermal Specifications

The Celeron processor on 0.13 micron process in 478-pin package, requires a thermal solution to maintain temperatures within the operating limits as set forth in Section 6.1.1. Any attempt to operate the processor outside these operating limits may result in permanent damage to the processor and potentially other components within the system. In addition, as processor technology pushes to faster speeds and higher performance, thermal management becomes increasingly crucial when building computer systems. Maintaining the proper thermal environment is key to reliable, long-term system operation.

A complete thermal solution includes both component and system level thermal management features. Component level thermal solutions can include active or passive heatsinks attached to the processor Integrated Heat Spreader (IHS). Typical system level thermal solutions may consist of system fans combined with ducting and venting.

For more information on designing a component level thermal solution, refer to the *Intel® Pentium® 4 Processor in the 478-pin Package Thermal Design Guidelines*.

6.1.1 Thermal Specifications

To allow for the optimal operation and long-term reliability of Intel processor-based systems, the system/processor thermal solution should be designed such that the processor remains within the minimum and maximum case temperature (TC) specifications at the Thermal Design Power (TDP) value or lower listed per frequency in Table 38. Thermal solutions not designed to provide this level of thermal

capability may affect the long-term reliability of the processor and system. For more details on thermal solution design, please refer to the appropriate processor thermal design guidelines.

The case temperature is defined at the geometric top center of the processor IHS. Analysis indicates that real applications are unlikely to cause the processor to consume maximum power dissipation for sustained time periods. Intel recommends that complete thermal solution designs target the Thermal Design Power (TDP) indicated in Table 38 instead of the maximum processor power consumption. The Thermal Monitor feature is designed intended to help protect the processor in the unlikely event that an application exceeds the TDP recommendation for a sustained time period. For more details on the usage of this feature, refer to Section 7.3. To ensure maximum flexibility for future requirements, systems should be designed to the Fixed Mobile Solution (FMS) guidelines, even if a processor with a lower thermal dissipation is currently planned. In all cases, the Thermal Monitor feature must be enabled for the processor to remain within specification.

6.1.2.1 Processor Case Temperature Measurement

The maximum and minimum case temperature (TC) for the Celeron processor on 0.13 micron process in 478-pin package is specified in Table 38. This temperature specification is meant to help ensure proper operation of the processor. Figure 36 illustrates where Intel recommends TC thermal measurements should be made.

7.3 Thermal Monitor

The Thermal Monitor feature helps control the processor temperature by activating the Thermal Control Circuit (TCC) when the processor silicon reaches its maximum operating temperature. The TCC reduces processor power consumption as needed by modulating (starting and stopping) the internal processor core clocks. The Thermal Monitor feature must be enabled for the processor to be operating within specifications. The temperature at which Thermal Monitor activates the thermal control circuit is not user configurable and is not software visible. Bus traffic is snooped in the normal manner, and interrupt requests are latched (and serviced during the time that the clocks are on) while the TCC is active.

When the Thermal Monitor feature is enabled, and a high temperature situation exists (i.e., TCC is active), the clocks will be modulated by alternately turning the clocks off and on at a duty cycle specific to the processor (typically 30-50%). Clocks will not be off for more than 3.0 microseconds when the TCC is active. Cycle times are processor speed dependent and will decrease as processor core frequencies increase. A small amount of hysteresis has been included to prevent rapid active/inactive transitions of the TCC when the processor temperature is near its maximum operating temperature. Once the temperature has dropped below the maximum operating temperature, and the hysteresis timer has expired, the TCC goes inactive and clock modulation ceases.

With a properly designed and characterized thermal solution, it is anticipated that the TCC would only be activated for very short periods of time when running the most power intensive applications. The processor performance impact due to these brief periods of TCC activation is expected to be so minor that it would be immeasurable. An under-designed thermal solution that is not able to prevent excessive activation of the TCC in the anticipated ambient environment may cause a noticeable performance loss, and in some cases may result in a TC that exceeds the specified maximum temperature and may affect the long-term reliability of the processor. In addition, a thermal solution that is significantly under-designed may not be capable of cooling the processor even when the TCC is active continuously. Refer to the *Intel® Pentium® 4 Processor in the 478-pin Package Thermal Design Guidelines* for information on designing a thermal solution.

The duty cycle for the TCC, when activated by the Thermal Monitor, is factory configured and cannot be modified. The Thermal Monitor does not require any additional hardware, software drivers, or interrupt handling routines.



Documentation Changes

The Documentation Changes listed in this section apply to the following documents:

- *Intel® Celeron® Processor in the 478-Pin Package Datasheet*
- *Intel® Architecture Software Developer's Manual*, Volumes 1, 2, and 3

All Documentation Changes will be incorporated into a future version of the appropriate Celeron processor documentation.

Note: Documentation changes for IA-32 Intel(R) Architecture Software Developer's Manual volumes 1, 2, and 3 will be posted in a separate document " IA-32 Intel(R) Architecture Software Developer's Manual Documentation Changes". Please follow the link below to become familiar with this file.

[<http://developer.intel.com/design/pentium4/specupdt/252046.htm>](http://developer.intel.com/design/pentium4/specupdt/252046.htm)